

# BEYOND COORDINATION: JOINT PLANNING AND PROGRAM EXECUTION

## *The IHPRPT Materials Working Group*

BY

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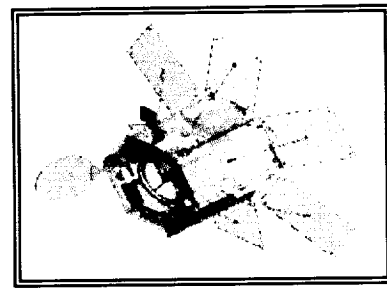
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### **Introduction**

"Partnership is more than just coordination," stated then-Commander of the Air Force Research Laboratory (AFRL), Major General Dick Paul (USAF-Ret), at this year's National Space and Missile Materials Symposium. His comment referred to the example of the joint planning and program execution provided by the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Materials Working Group (IMWG). Most people agree that fiscal pressures imposed by shrinking budgets have made it extremely difficult to build upon our existing technical capabilities. In times of sufficient budgets, building advanced systems poses no major difficulties. However, with today's budgets, realizing enhanced capabilities and developing advanced systems often comes at an unaffordable cost. Overcoming this problem represents both a challenge and an opportunity to develop new business practices that allow us to develop advanced technologies within the restrictions imposed by current funding levels.

Coordination of technology developments between different government agencies and organizations is a valuable tool for technology transfer. However, rarely do the newly developed technologies have direct applicability to other ongoing programs. Technology requirements are typically determined up-front during the program planning stage so that schedule risk can be minimized. The problem with this process is that the costs associated with the technology development are often borne by a single program. Additionally, the potential exists for duplication of technical effort. Changing this paradigm is a difficult process but one that can be extremely worthwhile should the right opportunity arise. The IMWG is one such example where NASA, the DoD, and industry have developed joint requirements that are intended to satisfy multiple program needs. More than mere coordination, the organizations comprising the group come together as partners, sharing information and resources, proceeding from a joint roadmap.

General Paul asserted that materials and process technology is key to our Nation's future. Materials are one of the most limiting factors for all future space systems. For instance, space-launch applications require lightweight, affordable, durable, reliable, high temperature materials. Moreover, these materials must be easy to inspect to facilitate quick vehicle turnaround. The current state of the art in materials and process technology will not provide the Air Force and NASA with cheap and routine access to space—an absolute must to ensure 21<sup>st</sup> Century America with a lasting and robust presence in the final frontier. Aside from the launch vehicles, communication and surveillance satellites require lightweight, durable materials for increased power and improved data processing. Continuing the upward trend in satellite power requires better thermal management for radiators, thermal planes, thermal control paints, and higher temperature semiconductors. Additionally, improved optics and detector materials will enable the development of future surveillance satellites.



Revolutionary material technologies are needed, and will take a generation or more to achieve. General Paul further stated that "We as a Nation must be investing our resources in this science now, as longer lead times are needed for materials technology advancement. Breakthroughs cannot be scheduled." In other words, the Nation's space and defense communities must make the development of leading edge materials technologies a national priority. Developing these materials within today's budgetary constraints can be accomplished more effectively by establishing formal partnerships that leverage funding from multiple programs and using these resources to develop common technologies. The IMWG is one such example, and other government funded technology development programs could benefit by applying the process discussed here.

### **Shrinking R&D dollar**

While many agree that the continued introduction of newly developed advanced materials is crucial to our Nation's interests, a recent National Academy of Sciences report indicated a disturbing shift in federal and industry priorities away from long-term research. According to the report, the consequences of such oversights are already becoming apparent:

- Government and industry funding is focused on short term research
- DOD funding for materials research is eroding
- Industry is eliminating or cutting back on research and development

The impact of the reductions to our materials research efforts manifests themselves in several areas. The reliance on short-term research focuses our efforts into lower-risk initiatives but achieving revolutionary jumps in technology requires the opposite approach. Greater emphasis must be placed on fundamental and long-term research to ensure technology breakthroughs continue. Another symptom of funding shortfalls is that oftentimes the materials technologies required to enable advanced system development are not yet available. This problem has a ripple effect in that funding for the acquisition program depending on the new materials technology becomes threatened due to the schedule slippage. The final point concerns our future. Government funding of university research has traditionally developed the trained technical workforce needed for our society to continue to advance. Limited funding to academic research centers is making it more difficult to attract new students into technical programs. The net effect is that materials development programs needed to enable revolutionary system advances are now unaffordable and could face even worse problems in the future unless we depart from past practices and enter into unique partnerships as described here.

### **About IHRPT**

To help put the discussion of IMWG into context, we should first touch briefly on the IHRPT program itself. The Integrated High-Payoff Rocket Propulsion Technology program, or IHRPT, is a DOD/NASA/industry initiative intended to double rocket propulsion capability by 2010. The program began in 1995. The IHRPT approach is to develop and satisfy a set of firm,

challenging, but attainable propulsion technology goals that are time-phased and measurable. IHRPT is not focused on developing any one specific propulsion system but instead is looking at the overall propulsion needs and then developing common advanced component technologies that can be tailored to meet specific operational requirements. For example, mission requirements for satellite or manned space flight launch vehicles differ considerably from tactical weapon delivery systems. As a result, military missiles can and do look considerably different from commercial or civil launch vehicles (see Figure 1). Yet, the propulsion systems from these different applications have a large degree of commonality. Hence, the components required to construct these military, civil, or commercial rockets are extremely similar providing a prime opportunity to jointly exploit technologies that meet the technical requirements of multiple applications.

The IHRPT program is based on a national plan, which is supported by a series of subplans from industry designed to cooperatively ensure the consolidated goals are met. The IHRPT team is responsible for using this plan to establish the required program budgets and schedules. All resulting technology advancements will be available for use in new and/or existing military, civil, and commercial propulsion systems. The time phasing will make demonstrated improvements available in an incremental manner when such technology is required.

IHRPT planning identifies the technologies that have the highest potential benefit to systems and focuses the government and industry resources on developing them. Multi-year development periods can proceed without interruption. To maximize technology transition opportunities, technology demonstrations will be conducted in configurations that verify the maturity of the technology and show that it is ready to be applied in any specific system.

Integrated planning teams have defined four technology areas requiring investment and are establishing the plans to achieve the goals. Since formulating technology plans for a 15-year period necessarily involves a high level of uncertainty, they represent the best current judgment and continue to evolve in detail as more knowledge is acquired.

A major part of the planning process involved an analysis of component level needs. While NASA, the military services, and industry each develop goals specific to the needs of their own stated mission, they will be folded into the IHRPT goals if appropriate. All IHRPT members have a vested interest in meeting IHRPT goals, but each organization derives different benefits from them. For example, the major thrust for NASA is affordable space transportation while the Air Force thrust revolves about aircraft-like operations such as faster turnaround, quicker alerts; more sorties; easier maintenance, and all weather capability. Finding commonality of requirements in such disparate operational philosophies is the crux of the IHRPT program.

### **The IHRPT Materials Working Group - IMWG**

Given the criticality of materials development and the shrinking research dollar, DOD, NASA, and the rocket propulsion industry are banding together to address materials needs for the next generation rocket propulsion systems. The emergence of new, state of the art materials will be the major factor contributing to the success of the IHRPT program. Thus the need for a focused and unified materials development effort was recognized at the beginning. The IHRPT Steering Committee chartered the IHRPT Materials Working Group, or IMWG, in February of 1997 to address this need. The group's primary function is to evaluate requirements and develop a materials plan to meet IHRPT program goals in liquid, solid, and spacecraft propulsion. Material and process technologies are sufficiently pervasive in the many facets of propulsion that they naturally lend themselves to joint planning. Thus, the IMWG steering committee is developing a combined roadmap for all materials development efforts. By this approach, the program will jointly leverage funding from various government organizations and industry to reach common goals.

## The IMWG Team

The initial membership of the team was comprised of technical representatives from various NASA, Air Force, Army, and the Navy organizations; as well as representatives from the major propulsion contractors (see Table 1). The working group is currently co-chaired by Mr. Michael Stropki of the Air Force Research Laboratory's Materials and Manufacturing Directorate (AFRL/ML) and Dr. Corky Clinton from NASA's Marshall Space Flight Center's (MSFC) Engineering Directorate. In the future, other organizations will be represented in the working group including material vendors and the Ballistic Missile Defense Organization (BMDO) – which is responsible for both the National Missile Defense (NMD) and Theater Missile Defense (TMD) programs.

Government	Industry	
USAF – AFRL	ARC	Primex
Army – ARL, AMCOM	Aerojet	Thiokol
Navy – NAWC, NSWC	Alliant	TRW
NASA – MSFC, GRC	Boeing/Rocketdyne	UT Chemical Systems
	Kaiser-Marquardt	UT Pratt & Whitney

Table 1. IHPRT Materials Working Group Partners

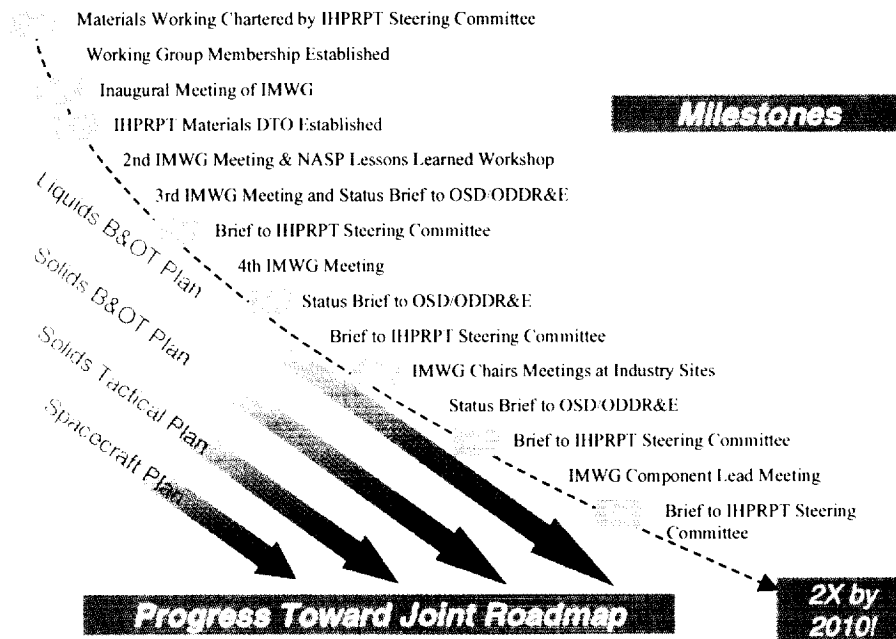


Figure 2. IHPRT Materials Technology Roadmap Development

## IMWG Process – The Steps to a Combined Roadmap

One of the primary activities of IMWG is to develop materials plans for IHPRT liquid, solid, and spacecraft propulsion goals as part of an overall joint roadmap for the program (See Figure 2.) The figure illustrates the four materials plans in parallel with significant IMWG milestones. Significant progress has been made on the plans for all aspects of rocket propulsion. The plans

are being developed independently with their individual technical requirements then being “rolled up” into a consolidated listing of materials needs, the IMWG Roadmap. These needs will then dictate that the resulting materials development programs offer tailored solutions to specific component requirements.

The four materials development plans were first briefed to the IHRPT steering committee in February 1999. Two of these plans are being developed to address the requirements for advanced solid rocket motors. One of these plans focuses on rockets used for boost and orbit transfer (B&OT) and the other discusses specific military requirements relevant to tactical missiles. The two remaining plans address spacecraft propulsion and liquid B&OT requirements. Industry and government participants (component and materials leads) cooperatively developed the prioritization of categories. It is important to note that the execution of each plan is a continuing iterative process. Once the plans have been developed, IMWG adhered to the following process to ensure successful technology development:

- Developed materials execution / funding allocation per plan
- Coordinated with IHRPT components leads and adjusted as necessary
- Coordinated with NASA plans in materials technology for integrated space transportation plan (ISTP)
- Obtained IHRPT steering committee approval to proceed
- Executing plan through a PRDA (see Acquisition Strategy)

In addition, an evolution to the IMWG materials plan is also currently underway. Under the leadership of the IMWG, an expanded scope of the IHRPT materials plan would merge the NASA propulsion materials planning for the Integrated Space Transportation Program with the IHRPT materials plan. The end product of this activity would be a “National Materials Plan” for advanced rocket propulsion. As a result of a recent IHRPT Steering Committee, Dr. John Rogacki, (Director of NASA’s Space Transportation Office at Marshall Space Flight Center), along with the Office of the Secretary of Defense’s Research and Engineering Office, gave the IMWG the charter to pursue the development of this plan. A future second evolution to this direction would be the eventual merging of the IHPTET (Integrated High Payoff Turbine Engine Technology) materials planning with the National Rocket Propulsion Materials Plan resulting in a common materials plan for all advanced propulsion, i.e. a “National Materials Plan for Propulsion”.

### **IHRPT Materials Plan**

The key to meeting IHRPT program goals is selecting the correct material development projects. The criteria for choosing projects are to select those that offer the highest payoff for their respective components and technical area with the greatest likelihood of success. This is accomplished by first looking at component level needs, determining those components that offer the highest potential for improving propulsion efficiency, analyzing alternative materials that show promise to enable the newly designed component, and selecting the materials development program offering the best solution. Figure 3. illustrates this process for selected propulsion management devices. To the left of the figure, components are ranked in order of system level payoff (according to overall IHRPT goals). The corresponding potential materials approaches are listed to the right.



## **Acquisition Strategy**

The IMWG will depart from traditional acquisition strategies to promote the development of program critical technologies. Specifically, the IMWG will try to ensure technical transition by defining component-driven tasks, such as pump housings, ducts, and lines; as opposed to more materials-driven tasks, such as copper-based MMCs or nickel-based superalloys. As such, the component-driven approach will more likely yield a material solution to a technical or performance challenge, because the needs of the component or system will provide focus to the development work. Specific projects will be solicited through the use of the Project Research and Development Announcement process, or PRDA. Contract awards for the various projects are scheduled for December 1, 2000, with work starting shortly thereafter. Each approved materials development program must comply with the ground rules set by the IHRPT steering committee for PRDAs (and monitored by IMWG):

## **Tech transition: Spin-offs**

The concept of IMWG is already catching on – An effort is currently underway to form a materials working group to support the development of advanced thermal protection systems (TPS). TPS are used to protect spacecraft from the extreme temperatures experienced during launch and reentry environments. A good discussion on various TPS systems is contained in the MaterialEASE found in this issue of the AMPTIAC Newsletter. There are currently a number of programs sponsored by NASA and the DoD that are developing the technologies needed to enable the next generation of reusable spacecraft. The DoD is developing the Common Aero Vehicle (CAV), the Space Operations Vehicle (SOV), and the Space Maneuvering Vehicle (SMV). NASA is concentrating on a number of programs including the "X" series of craft (X-33, X-34, X-37, Hyper-X, and Future-X), all technology pathfinders for the future. Historically TPS has been a limiting factor in space vehicles exposed to extremely high temperatures. One of the "weak-links" that preclude rapid servicing and reuse of the Space Shuttle lies in the thermal protective tiles. These materials are extremely effective at protecting the structure during flight but they are fragile and prone to moisture absorption resulting in excessive maintenance requirements. Many of the programs currently underway are working with TPS technologies that show tremendous promise for greatly reduced maintenance following each mission.

The development of a materials working group to support advanced TPS is a logical extension of the IMWG. The TPS community will face many of the same issues of concern to the IHRPT IMWG. In fact, many of the organizations involved in TPS are also involved with the IMWG.

## **Conclusions**

The key to IHRPT success is the common shared vision by its advocates. More people are realizing the benefits (and necessities) of working together, sharing information, and joint planning – 'Much more than coordination', as General Paul intimated. Proceeding from a joint roadmap, Industry is working towards common goals, consistent with program requirement specifically and defense/aerospace technical objectives in general. IMWG will continue throughout the life of IHRPT. It will adhere to a "living plan" expanding to accommodate other potential team members, such as material suppliers and BMDO. Potentially, the key industry participants may be expanded as well to include micromechanical modelers, testing, manufacturing, and non-destructive inspection experts. However, there will be no international participation, as propulsion technology is export controlled. Government technical teams will provide oversight. The combined guidance of NASA and AFRL provides a unique leadership role set up to do what is right for the Nation's defense and aerospace interests.

The goals of the IHRPT program are very aggressive and ambitious, requiring numerous materials-enabling technologies to meet system requirements. As a result of the process, the IHRPT Materials Working Group has established a model for future programs to follow. While the evolution of this process has been taxing, future efforts will have the infrastructure in place to establish their respective working groups more readily. Buy-on to this process has not been

universal by any means. As IHPPT reaps the fruits of its labors, others will see the value of partnerships and wholeheartedly subscribe to the process.

While the collaborative environment created by the IMWG approach to developing technology is especially useful in these lean times, it would be appropriate in any era, representing a significant benefit to the taxpayers. These benefits are realized both in terms of cost-savings and technical output. A single, unified effort drawing from all contributors would most certainly yield greater technical dividends than multiple parallel projects. Shared data between teaming organizations would eliminate waste, and hence avoid duplicate efforts.

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